Notes: Relative Dating

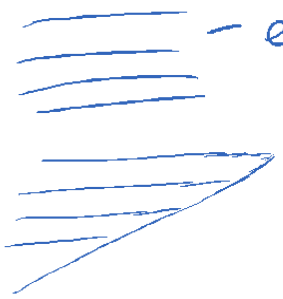
- Placing events in the proper sequence, oldest to youngest, by comparing.

5 Quick Rules

1. Principle of Superposition

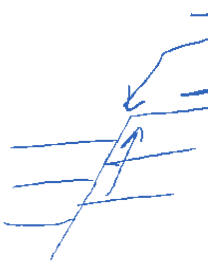
- in an undisturbed pile of sediments (or sedimentary rock) unaffected by folding, faulting, etc. those on the bottom were deposited 1st followed by the layers on top with the youngest on top.

2. Principle of Horizontality



- especially on a large scale, sediments are commonly deposited in approximately horizontal, flat-lying layers (ie snow fall evens out lumps)
- folds and steep tilts are from deformation after deposition and lithification.

3. Principle of Cross-Cutting Relationships



- if a fault, dike or other pluton cuts across layers of sed. rocks, the sed rocks must have been there

first.
- intrusions may have also metamorphosed the country rock adjacent to it (contact metamorphism)
- intrusion may have chilled margins along edges (small crystals since cooled faster)

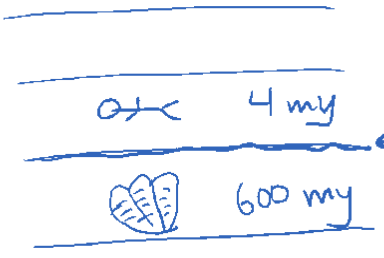
4. Principle of inclusion

- If a pluton contains xenoliths (included fragments of other rocks) the rock from which the xenolith came must pre-date/be older than the intrusion (xenolith/included fragment is older; true for pebbles in conglomerate too)

5. Unconformity

- a surface within a sedimentary sequence where there was a lack of deposition or even some erosion for a period of time.

A. Disconformity - an unconformity at which the sed. layers above and below are parallel. (Hard to recognize; look for weathered surface on strata below, or very diff. ages right next to each other)



next to each other)

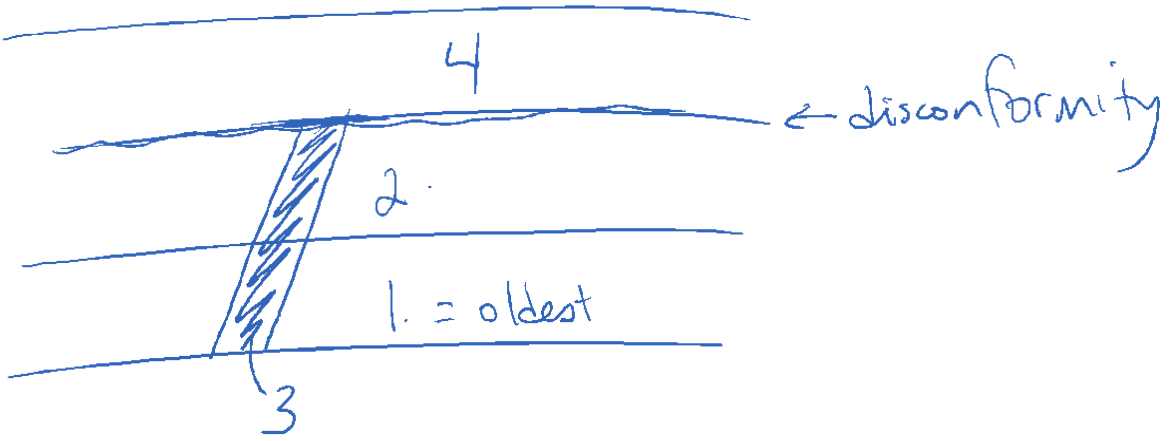
B. Angular unconformity
- bedding planes above and below the unconformity are not parallel (uplift and erosion has occured)

① deposition 

② uplift/tilt 

③ erosion + deposition 

Ex



Distinguishing between

sill	buried lava flow
	
- has contact meta morphosed layers above and below	- has only contact meta the layer below lava flow may have

- has contact with morphosed layers above and below
- could have inclusions from layers above + below

the layer below
- lava flow may have inclusion from layer below
- layer above may have inclusions of the lava flow
- may have vesicles as gas under less pressure undissolves and bubbles out

Workbook - pg 1-4

Geology 12
Geologic Time

Relative Ages Exercise.

The following 9 cross sections represent hypothetical strata of the earth. Write your answers in the space beside each section.

Questions.

1. (a) State the Law of Superposition.
   (b) List the strata in order from oldest to youngest. (It is convention to always list from oldest to youngest or to write in a column with the youngest at the top.)

2. (a) Complete the list in the column.
   (b) Which event occured first?
   (c) Which event occured last?
   (d) State the Law of Original Horizontality.

3. (a) Complete the list.
   (b) What occured at P ?
   (c) What is a feature like P called?

4. (a) What occured first?
   (b) What occured between the deposition of A and K ?
   (c) What was the last event to have occured?

5. (a) Complete the list.
   (b) How do you know where to put A in the series?
   (c) What is A called?

6. (a) Complete the list.
   (b) What occured at Y ?
   (c) What could have occured between B and C ?
   (d) When did the tilting take place compared to dyke X ? How do you know?

7. (a) Which is the oldest?
   (b) What is Z ? What type? How do you know?
   (c) What happened between X and N ?

8. (a) List in conventional order.
   (b) What type of feature is E ?
   (c) What would you notice along the margins of A ? Why?
   (d) BONUS: Name the type of rock you would probably find between C and A.

9. (a) List the Igneous activity in order from oldest to youngest.
   (b) What are two pieces of evidence for the order of dykes C and D ?

Legend for Rock Types:

Limestone - 

Sandstone - 

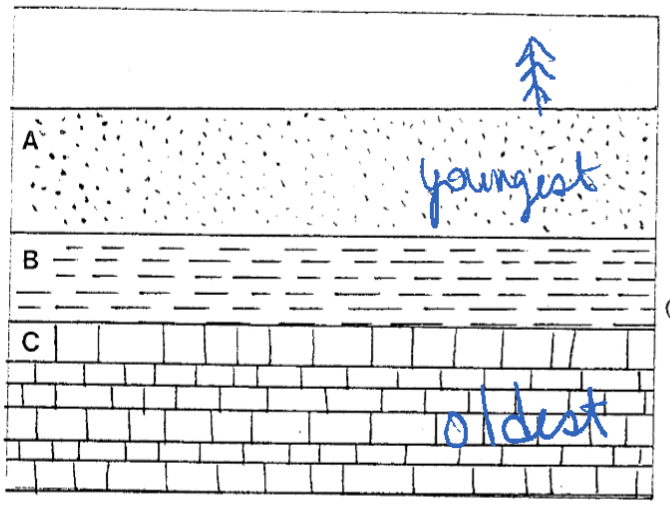
Shale - 

Conglomerate - 

Volcanic - 

Plutonic - 

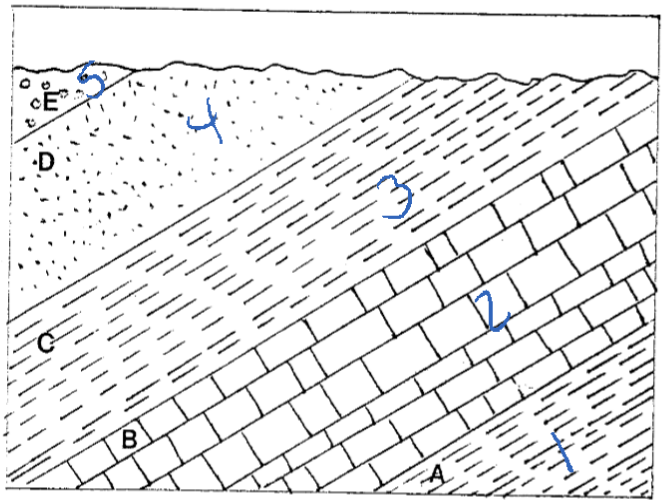
1.



(a) Superposition - oldest on bottom, youngest on top.

(b) oldest C B A youngest

2



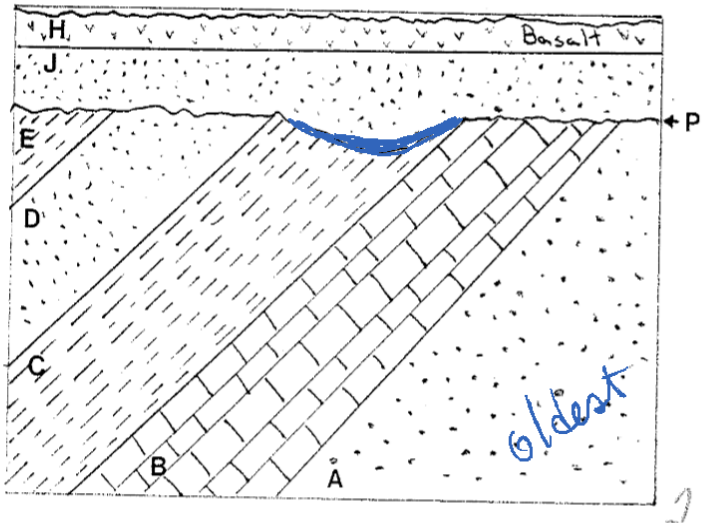
(a) youngest E
D
C
B
oldest A

(b) deposition of A

(c) tilting + erosion

(d) orig horiz - layers deposited horizontally then lithified.

3

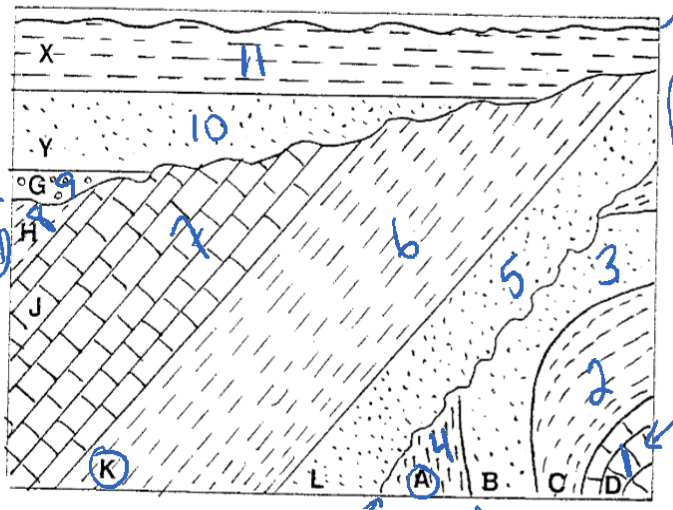


(a) youngest H
J
E
D
C
B
oldest A
← P

(b) tilting + erosion - "missing time" - no layers to represent that tilt/erosion period.

(c) angular unconformity

4.



erosion

tilt + erosion (ang. unconf)

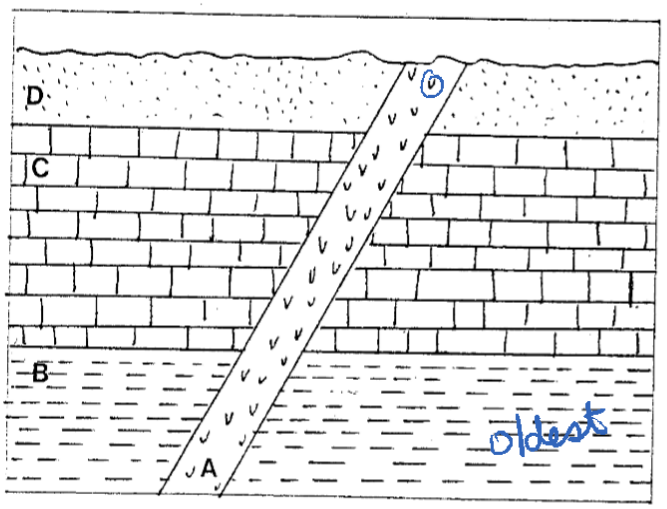
ang. unconf. (fold + erosion)

(a) dep of D

(b) A lithified, then D-A folded, eroded, L and K deposited.

(c) erosion of X

5

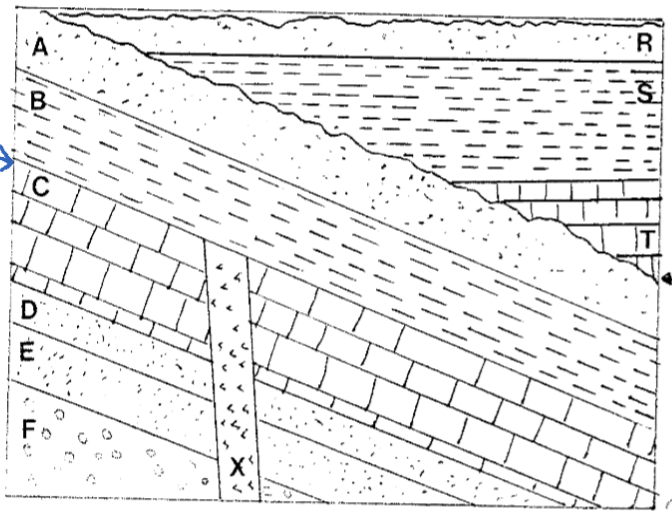


(a) youngest
A
D
C
B

(b) A cuts across all the layers, so it must be younger (principle of cross-cutting)

(c) dike

6



disconformity ?

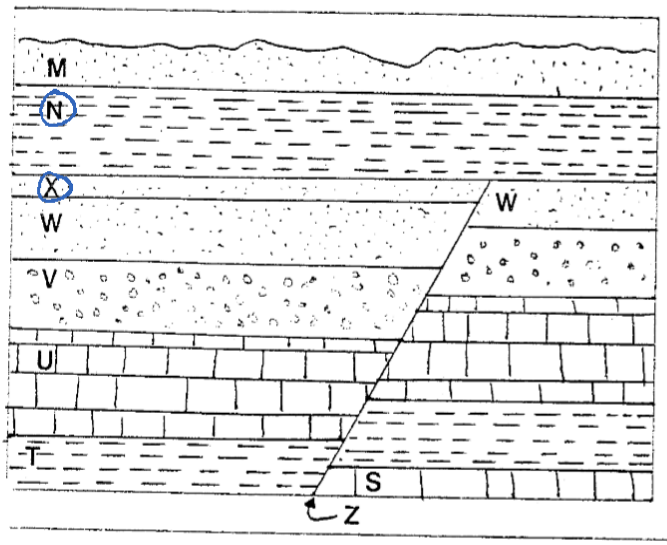
(a)
R youngest
S
T ← y
A
B
X
C
D
E
F oldest

(b) erosion + tilting

(c) betwn B + C may have had some erosion - disconformity

(d) tilt after X since layers B & A were dep before tilt (princip. of horiz)

7.

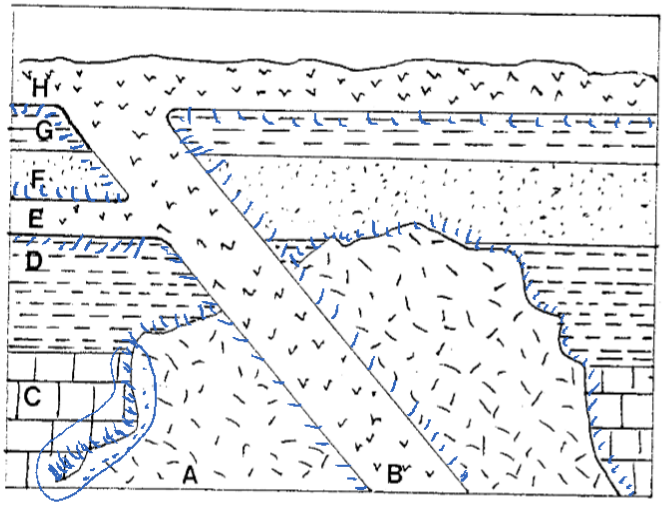


(a) layer S

(b) normal fault
- hanging wall slid down the foot wall

(c) fault + erosion
- disconformity

8



oldest ⟷ youngest

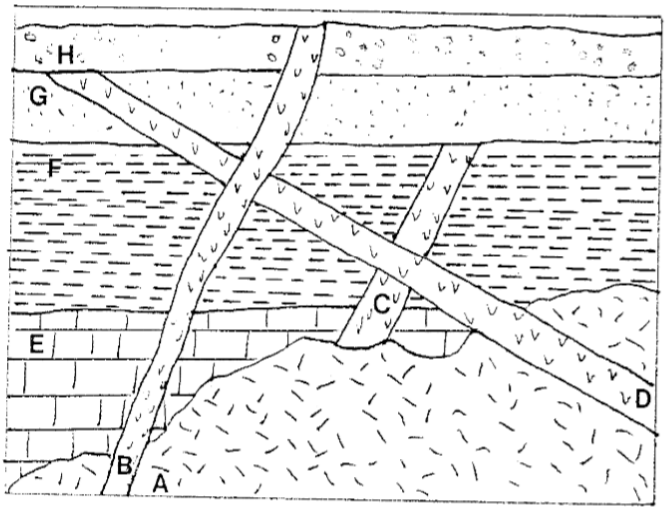
(a) C, D, F, A, G, B, E, H

(b) sill = E

(c) chilled margins inside A contact meta in country rock

(d) Bonus, meta limestone = marble

9



ig. activity

(a) oldest C, A, D, B youngest

(b) - D cuts across C
- C is behind (older) A and D cuts across A (younger)

GEOLOGY 12 Name _____
CHAPTER 8
EXERCISE 13 DATING OF ROCKS AND GEOLOGIC EVENTS

- Refer to the lab manual pages 196-204.
- Review and make notes on the background information as necessary.
- Complete question #3 page 200 and #5 on page 202.

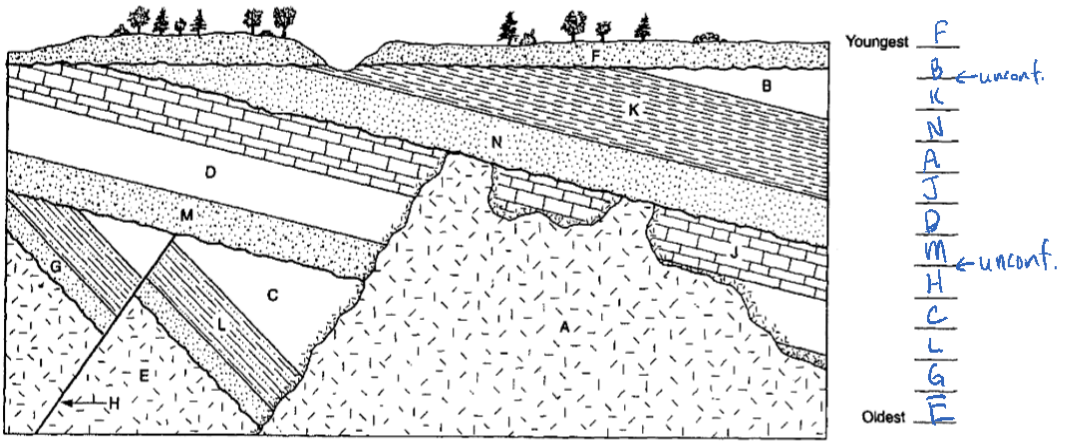


Figure 13.14

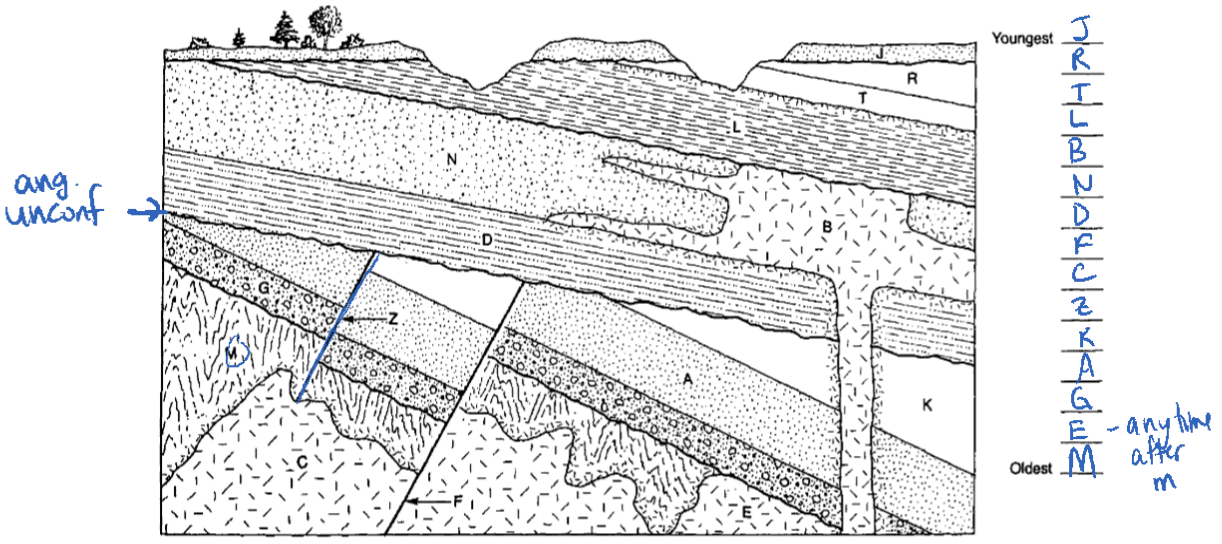


Figure 13.15

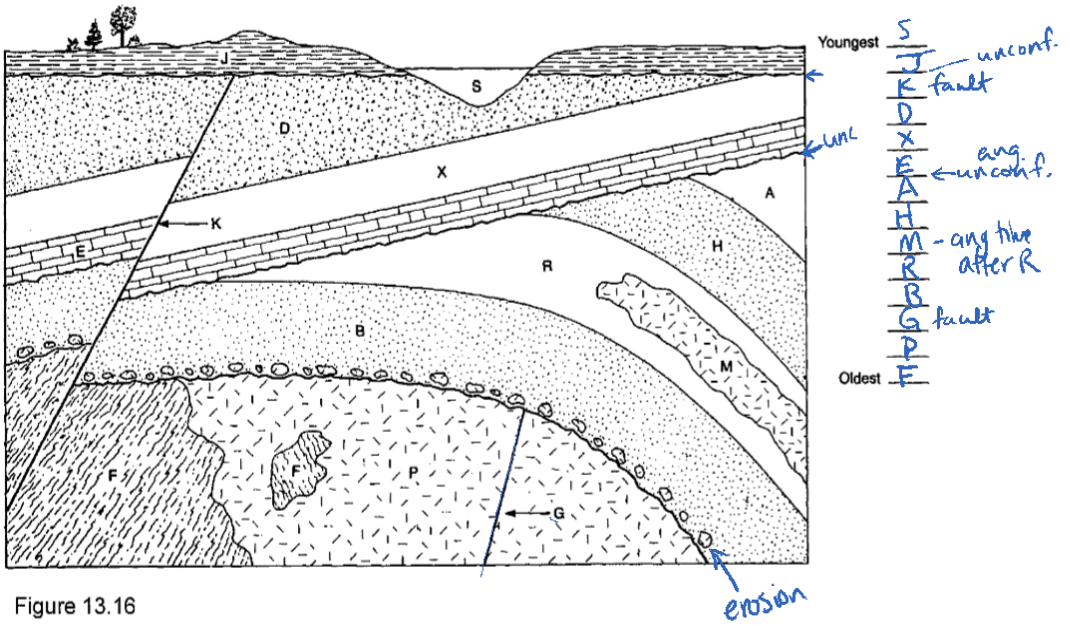


Figure 13.16

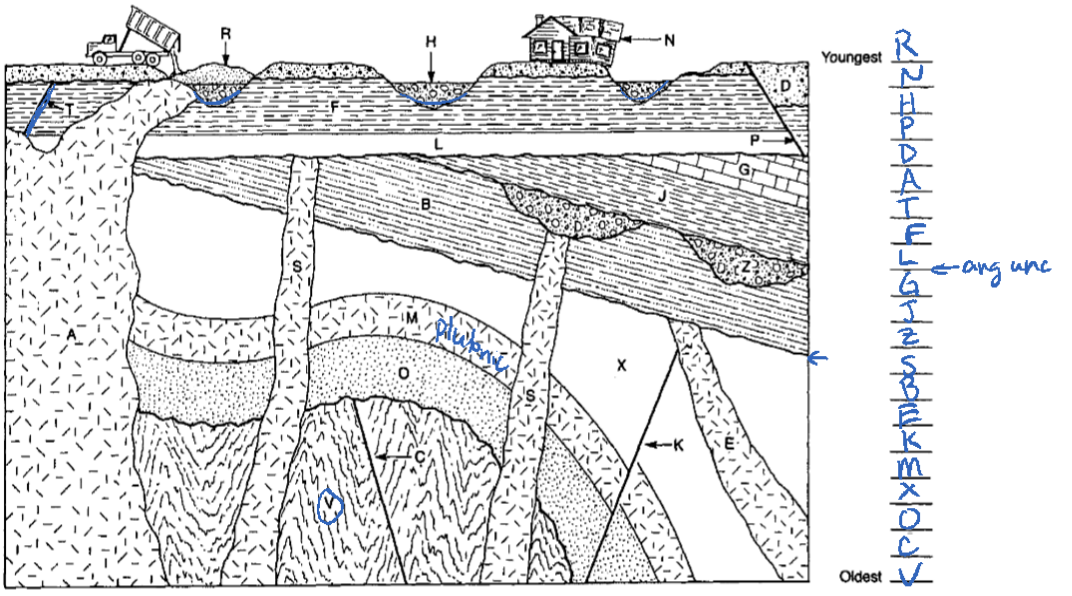


Figure 13.17

- Attach your answers to question #5 and submit for marks.

pg 156-158 – Early ideas of age of ⊕

radioactive isotopes – unstable nucleus (parent) so, in time, it decays changing into a different nucleus that is stable (daughter)

[produces heat – believed to provide the heat that has kept ⊕ molten inside providing energy for plate tectonics]

radiation of decay – alpha particles (α) (He nuclei = 2p+2n)
– beta particles (electrons, e^-, β)
– gamma rays (electromagnetic radiation, strongest energy)

ex carbon 14 (parent) decays by ejecting beta particles (e^-) and forms Nitrogen 14 (daughter)

C14 (8n 6p) ⟶ N14 (7n 7p)

(one n becomes one p + one e^- ejected)

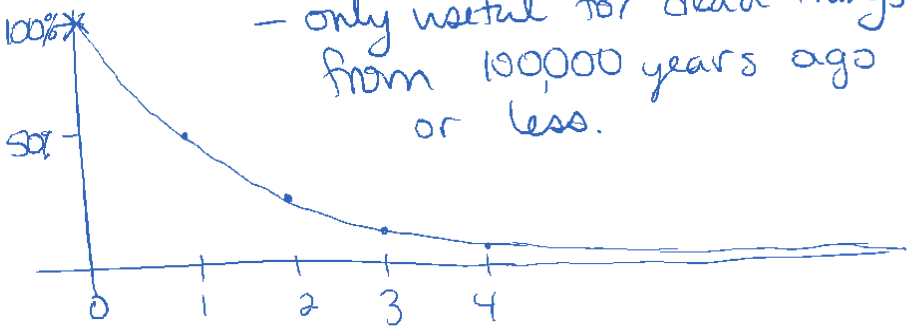
radioactive decay obeys the laws of probability:

half-life – length of time required for half of a given initial # of parent atoms to decay into the daughter isotope

half-life is constant for each element

✡ C14 h.l. = 5730 year

↳ can only be used for dead things (not rocks) (used to be alive)



- only useful for dead things from 100,000 years ago or less.

K-40 $\xrightarrow{1.25\ b.y.}$ Ar 40 gas

* U 238 $\xrightarrow{4.5\ b.y.}$ Pb 206

U 235 $\xrightarrow{704\ my}$ Pb 207

ex Dead tree sample has 16 Carbon 14 atoms and 48 Nitrogen 14 atoms. How long has tree been dead? h.l. = 5730 yrs

16+48 = 64 atom of C14 when tree died

64P $\xrightarrow{1\ h.l.}$ 32P, 32d $\xrightarrow{1\ h.l.}$ (16P, 48d) ∴ 2 h.l.

$$\text{Age} = \left(\begin{matrix}\#\text{ of} \\ \text{h.l.}\end{matrix}\right)\left(\begin{matrix}\text{length} \\ \text{of h.l.}\end{matrix}\right)$$

$= (2)(5730y)$

$= 11{,}460$ years since tree died

Possible Problems

- may have been some daughter present to start with (make rock look older)
- may not be a closed system - for ex. K-Ar, argon is a gas that can escape making rock look

younger

Choice of Isotope

- parent was/is abundant in sample
- h.l. appropriate to age being dated
- what are you dating?
  - dead thing - use C14 up to 100,000 y old
  - rock - any method, except C14
  - meta. rock - K-Ar since Ar escapes in meta processes, resetting the K-Ar clock

Absolute Age - numerical age from radiometric dating, counting tree ring, counting varves (layers at bottom of glacial lake)

We use a combination of relative and absolute dating methods.

pg 7 + graph (pg 9)

Geology 12
Radiometric Dating **Name:**

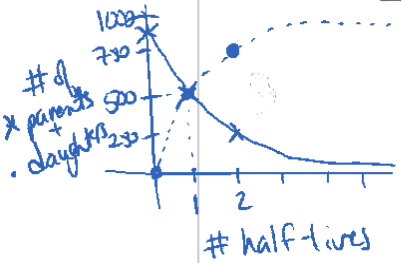
Set Up:

- Use as much of the graph paper as possible (make a big graph)
- Label the X-axis with number of half lives (0, 1, 2, … 10)
- Label the Y-axis with number of parent atoms (1 to 1000)

h.l.	P	d
0	1000	0
1	500	500
2	250	750
⋮		

Drawing the Graph:

- Begin with 1000 atoms of radioactive parent element and 0 atoms of stable daughter product.
- Plot points to draw the decay curve, showing the decrease in the number of parent atoms through ten half lives.
- Draw in the decay curve using a SMOOTH curve
- Plot points to draw the accumulation curve, showing the increase in the number of atoms of stable daughter product through ten half lives
- Draw in the accumulation curve using a SMOOTH curve
- Note: the half life of the radioactive element you graphed is given as 5730 years.



Questions based on your graph:

1. How many years are equal to 5 half lives? 5 × 5730
2. How many parent atoms will be left after 5 half lives? 1000P → 500P 500d → 250P 750d → 125 875 → 62 938 → 31P 969d
3. How many daughter atoms will be accumulated after 5 half lives?
4. At what point in time (number of half lives) will the number of parent atoms be equal to the number of daughter atoms? after 1 h.l.
5. At what point in time (number of years for this sample) will the number of parent atoms be equal to the number of daughter atoms? 5730 yrs.
6. At what point in time (number of half lives) will the number of daughter atoms be exactly three times the number of parent atoms? after 2 h.l. $\frac{750}{250} = 3$
7. How many half lives equals 22,920 years? 22920 ÷ 5730 = 4 h.l.
8. What element has a half life of 5730 years? Carbon 14
9. What is the stable daughter product of this element? Nitrogen 14
10. If you have 125 atoms of parent, how many daughter atoms will be present in this example? 875d + 125p = 1000 atoms from start
11. If you have 125 atoms of parent, how old (number of years) is the sample?

Age = 3 h.l. × 5730 yrs = 17,190 yrs

7

General Questions:

12. Define half life.

13. How many half lives have passed if a rock sample has:

- 50% daughter and 50% parent? 100P → 50P 50d — 1 h.l.
- 150 stable and 50 radioactive atoms? 200P → 100P 100d → 50P 150d — 2 h.l.
- 7/8 daughter and 1/8 parent? 1P → ½P ½d → ¼P ¾d → ⅛P ⅞d — 3 h.l.

14. What is the formula for calculating the age of a rock?

$$\text{Age} = \left(\frac{\#\text{ of}}{\text{h.l.}}\right)\left(\frac{\text{length of}}{\text{h.l.}}\right)$$

15. Calculate the ages for the above samples if the half life is 5 million years.

- 1 × 5my = 5my
- 2 × 5my = 10my
- 3 × 5my = 15my

16. True or false: uranium 238 dating can be used to find the age of a dinosaur bone? — no U in living/dead things

17. True or false: Carbon 14 can be used to find the age of a dinosaur bone? — all C14 is gone, dino's died too long ago

18. A piece of *wood* found in an ancient tomb has a ratio of 1 parent to 15 daughters.

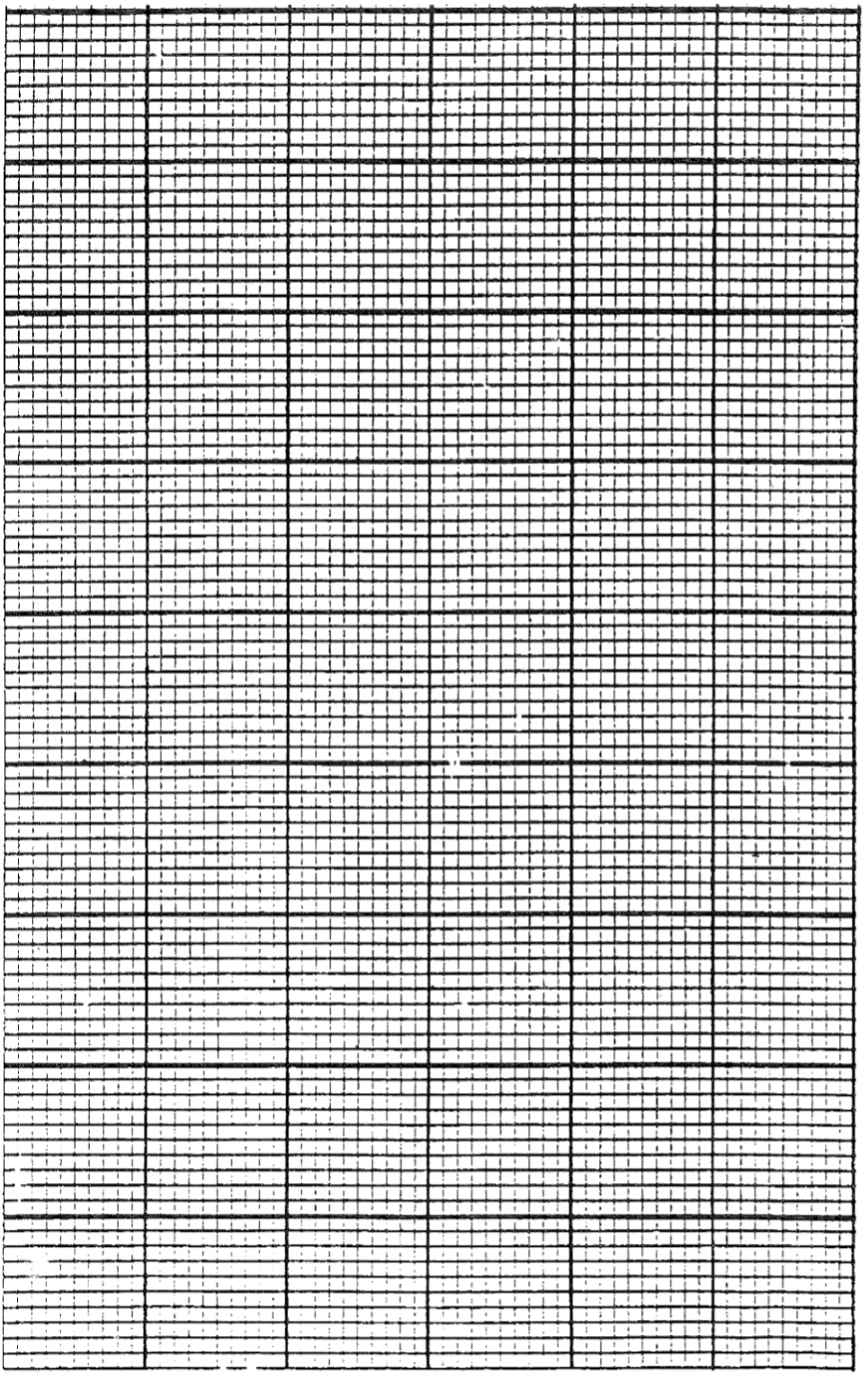
- How many half lives have passed? 16P → 8P 8d → 4P 12d → 2P 14d → 1P 15d — 4 h.l.
- How old is the wood? C14

4 h.l. × 5730 yrs = 22,920 yrs

19. Explain in detail how to find the age of a rock using radiometric dating.

Compare # of parents + daughters present to find out how many h.l. passed.
Use age formula

20. Make up a radiometric dating question and have your partner find the age.



Name:_____

Pg 10-12

Radiometric Dating

1. a. If a sample started with 100% parent and now has 75% daughter and 25% parent, how many half lives have passed? 2 h.l.

   b. If one half life is 7 million years, how old is the sample? 14 my

2. How long has a tree been dead if there is an equal amount of carbon-14 as nitrogen-14? 5730 yrs.

3. How much uranium-238 should be left on Earth compared to what was here when Earth formed 4.5 billion years ago? half

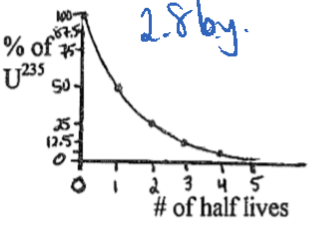
4. a. An igneous rock from some distant galaxy (brought here by aliens) contains 8 parents and 56 daughter atoms. How many half lives have passed? 3 h.l.

   b. If the parent is rubidium-87 and the daughter is strontium-87, how old is the sample? (Is this possible in our universe?!) 146.4 by.

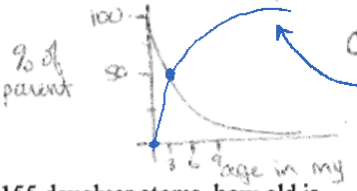
5. a. There was an earthquake that caused a rock containing argon-40 to fracture. Some of the argon escaped. How? argon is a gas

   b. What effect will this have on the apparent age of the rock? Will it look younger or older than it should? Explain. looks like less decaying

6. Given the following graph, how old is a sample that contains 6.25% parent and 93.75% daughter? 2.8 by.



b) What is the age of a rock if 75% is still parent (radioactive) ~1.5 my



7. If a piece of paper contains 5 parent atoms and 155 daughter atoms, how old is it? (Hint: what isotope must be being referred to in this case?) 28,650 yrs.

8. If the daughter to parent ratio is 7, how many half lives have passed? How old would the sample be if the parent were thorium-232 and the daughter lead-208? 42 b.y.

c:geolradd

10

WS Relative & Absolute Time

GEOLOGY 12 Name _____

CHAPTER 8 WORKSHEET #2

RELATIVE TIME AND ABSOLUTE TIME

Match the descriptions on the right to the persons on the left. Place the letter of the corresponding description in the blank by each name. You may use some descriptions more than once.

For fun...

E 1. Henri Becquerel
C 2. Lord Kelvin (reworked Buffon's)
D 3. Nicholas Steno
C 4. Georges Buffon
G 5. John Joly
B 6. William Smith
A 7. Archbishop Ussher
F 8. C.D. Walcott

A. calculated age of earth from number of generations in the Bible
B. proposed the Law of Faunal Succession
C. calculated age of earth based on cooling rate of the earth from an initially molten state
D. proposed the principles of Superposition and Original Horizontality
E. discovered radioactivity of uranium
F. calculated age of earth based on rates of sedimentation
G. calculated age of earth based on amount of salt in the oceans
H. calculated age of earth based on rate of "burning" of the sun – Kant

9. After two half-lives, how much radioactive parent isotope will be left in a given mineral?
A. 133% B. 50% (C.) 25% D. 33%

10. If the ratio of daughter isotope to parent isotope is 7, how many half-lives have passed?
A. can't tell from information given
B. seven
C. one
(D.) three

11. As each half-life passes, the amount of daughter product will
A. decrease by half each time
B. increase by doubling each time
C. never exceed the amount of parent isotope remaining
(D.) increase by the amount of parent isotope which has decayed

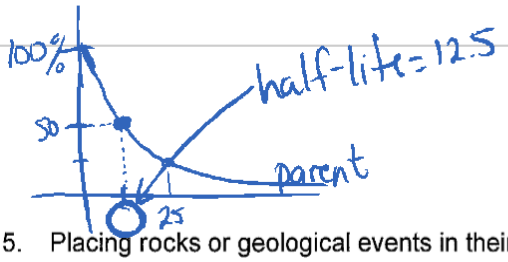
12. A mineral being used for radiometric dating contains 600 units of the daughter isotope and 200 units of radioactive parent isotope. How many half-lives have passed?
(A.) two
B. none
C. three
D. can't tell from the information given

13. A mineral contains an amount of daughter isotope equal to the amount of radioactive isotope remaining in it. The half-life for the radioactive isotope is 250 million years. How old is the mineral?
(A.) 250 million years
B. 125 million years
C. 500 million years
D. just formed; no decay has occurred

14. Rubidium-87 has a half-life of 48.8 billion years. Let's assume that radioactive rubidium would be safe to be around if there was less than 1/64 the original number of radioactive atoms left. How many years would that take?
A. about 800,000 years
(B.) a little over 290 billion years
C. about 3200 million years
D. cannot be calculated from the information given

11

100% half-life = 12.5



15. Placing rocks or geological events in their proper time order is known as relative dating.
16. In a sequence of sedimentary rock layers, the oldest rock is always on the bottom.
17. Sedimentary rocks, which are now folded or otherwise deformed, initially were deposited as horizontally layers of sediments.
18. A disconformity is a type of unconformity in which sedimentary rock layers are parallel above and below it.
19. An igneous dike or pluton is younger in age than the rocks which it cuts across.
20. The Law of Faunal Succession is useful because it allows geologists to correlate rock layers based on the fossils they contain.
21. In the nineteenth century, the age of the earth was thought to be considerably younger than it is today.
22. Radioactive decay affects the numbers of protons and neutrons in the nucleus of an atom.
23. Each alpha particle consists of two protons and two neutrons. (He atom)
24. Beta particles may be electrons or positrons.
25. Gamma rays are a form of electromagnetic radiation, similar to X-rays.
26. A mass spectrometer is used to measure the tiny amounts of parent and daughter isotopes in radiometric age dating.
27. Radioactive decay is a statistical phenomenon, "obeying" the laws of probability.
28. Potassium-40 will decay to the daughter isotope Argon-40 (gas). (1.25 b.y.)
29. Uranium-235 will decay to the daughter isotope Lead-207 (407 my.)
30. Of the radioactive isotopes used for age dating rocks, Rubidium-87 has the longest half-life. (48.8 b.y.)
31. Carbon-14, which has an extremely short half-life by geologic standards, is used primarily for age dating archeological artifacts. (5730 yrs)
32. If some of the daughter product has escaped from a mineral since the time that radioactive decay started, the derived age of the mineral (or rock) will appear to be too young.
33. The era of the geologic time scale that represents "middle life" is the mesozoic.
34. The shortest and most recent era of the time scale is the cenozoic.
35. Arrange the terms in order by age from oldest to youngest, as they are arranged in the geologic time scale : Paleozoic, Proterozoic, Cenozoic, Mesozoic, Archean

Cenozoic ← now
Mesozoic ← dinosaurs
Paleozoic ← explosion of life 600,000,000 yrs.
Proterozoic } Precambrian
Archaen ← 4,500,000,000 yrs

Macaroni Quiz

(in handouts for practice)

Name:_____

Radiometric Dating Quiz

Find the age, in years, of your sample. Show all your work in the space indicated.

Sample Number: _____

Each bag contains a sample representing a parent isotope and its stable daughter.

Parent:	^{28}Ma	macaronium 28 (natural colour)
Daughter:	^{24}Pa	pastanium 24 (green colour)

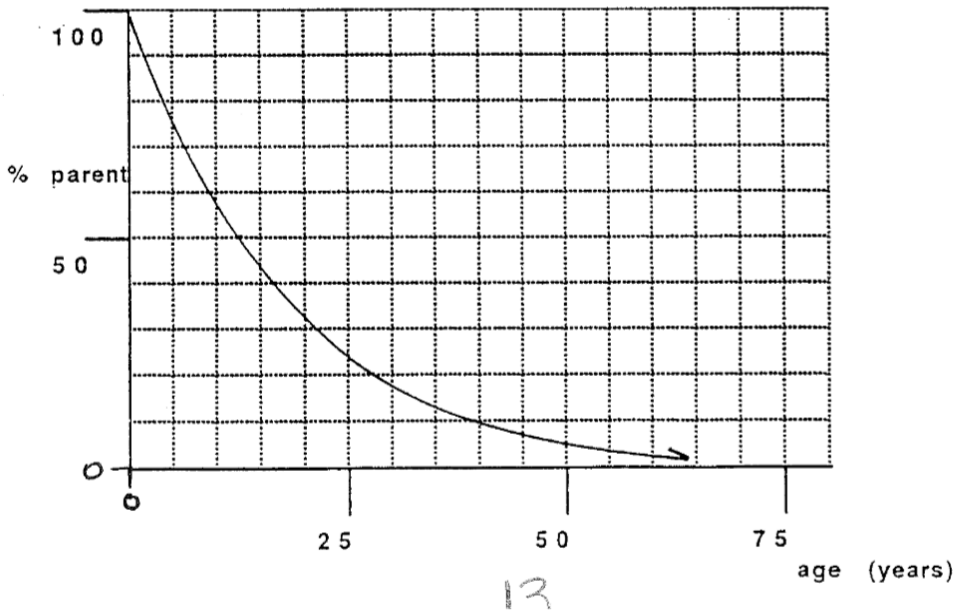
Caution: The atoms are fragile and not edible!

The decay curve for ^{28}Ma is given below.

SHOW ALL CALCULATIONS USED TO FIND THE AGE IN A NEAT ARRANGEMENT IN THIS SPACE.

Radiometric Age:_____

Bonus: Sketch the curve for the stable daughter on the graph.



3

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Name:_____

Chapter 8 Notes Continued

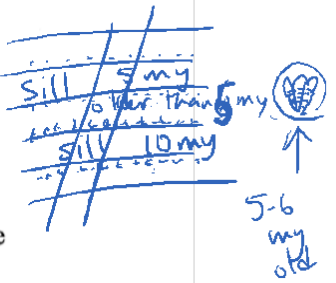
The Geologic Time Scale

The eon called the Phanerozoic takes up less than 15% of Earth's history and includes the following eras: Cenozoic - recent life, the age of the mammals
Mesozoic - middle life, the age of the reptiles
Paleozoic - ancient life, the age of the invertebrates

Eras are subdivided into periods and the periods of the Cenozoic into epochs

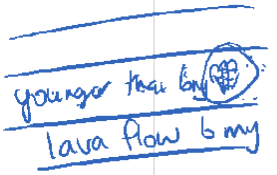
The names of periods and epochs are for the place where rocks of that age were well exposed and that time unit was consequently first defined.

The first divisions were done from faunal succession then radiometric dating (of dikes, etc. that cut through the sedimentary layers) gave numerical ages.



Precise dates for the Phanerozoic is difficult because
- sed. rocks and fossils can't readily be dated so had to approach it indirectly by determining age limits and making correlations
- radiometric dating has some uncertainty (between 1 and 10 %)

The Precambrian includes the 4 billion years of time before the Phanerozoic. There were basically no fossils to give a basis for divisions so it was divided into two parts (Archean and Proterozoic) almost arbitrarily. There was widespread igneous activity and mountain building but no single event of global impact.



See the Geological Time Scale, page 164 in text.

How old is the Earth? - A better answer.

No rocks have been preserved unchanged on Earth but we believe the sun, moon, meteorites, etc. formed at the same time
moon sample ~4.6 billion years old
meteorite sample ~4.5 -4.6 billion years old
gives us that the earth is ~4.55 billion years old

Oldest earth material is 4.4 billion years. Oldest rocks on each continent between 3.6 and 3.9 billion years. Why none at 4.55 billion years old?
- radiometric clocks start when rocks cooled (maybe was molten for long time.)
- rock cycle has been acting since the beginning, changing most rocks at least once

Earth's History - Quick Summary

Universe
- Big Bang occurred 13.7 billion years ago, still expanding, open/~~closed~~?

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Stars
- Matter not uniformly distributed so clumps join together due to gravity star is born
- stars burn up their fuel, create heavier elements, supernovae (blow up), spread heavy elements through space
- our earth and sun are made up of matter that likely was cycled through several generations of stars

Solar System
- our sun is middle aged, 5 billion years old, 5 billion years to go
- cloud of dust and gas condensed, most mass condensed to form Sun, rest into planets
- composition of planets depends on how close they are to sun, higher T materials nearest sun (Fe, etc.), "gases" (solid H, He, lighter elements) farther out

Earth
- dust ball condensed; heated by collisions of particles, compression by gravity and radioactive elements so most of the Earth was melted ← differentiation
- slowly cooled, heavy iron sunk light elements rose making the core, mantle, crust 4 billion years ago
- as cooled, water condensed in atmosphere
- early atmosphere contained almost no oxygen, blue-green algae and formation of limestone supplied oxygen
- many changes have occurred since ⊕ formed - continents moved, volcanoes, mountains, erosion, . . .

Life on Earth

0.5 million yrs ago	modern, rational Homo Sapiens, major impact in short time!
3-4 million	the most primitive humans developed
65 million	mammals become dominant (dinosaurs ~~decline~~ extinct)
150 million	warm blooded animals fly (birds)
200 million	dinosaurs and 1st mammals
400 million	insects, amphibians and reptiles onto continents
400-500 million	animals with backbones (fish) and land plants
600 million	marine animals with shells widespread
1 billion	1st multicelled, soft bodied, oxygen breathing creatures, poorly preserved, few fossils
4.6 billion yrs ago	formation of the earth

The practical aspects of learning this is that energy sources come from old plants and animals. If you know the time they lived then you know where to mine.

Dating and Geologic Process Rates
Continents move ~ 4 cm/yr relative to magnetic poles
Uplift rates ~ 1 cm/yr in mountain ranges, erosion rates similar
Must be cautious about extrapolating present process rates into past or future!
read page 170

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Time Scale Exercise

Geology 12
Geologic Time Scale Exercise Name: _____

Preliminary Information:
The easiest way to visualize the vast amount of time that the Earth and its past present life forms have existed is by means of a Time Line. In this exercise, you will be constructing a time line which will indicate some of the major events that have taken place on our planet. Adding machine tape will be used to plot such a line.

Procedure:

1. Obtain a 2.5 meter long piece of adding machine tape. Mark the far right-hand side as PRESENT, in red.
2. Using a scale of "1mm = 2 x 10^6 years (2 million)", plot the following by measuring back in time to the left.
    a. The Phanerozoic portion of the time scale, along with all its divisions, on the top edge of the tape.
        i. Eras marked in Red
        ii. Periods marked in Blue
        iii. Epochs marked in Green
    b. Arrange all of the following event s, in order, in black or pencil on the bottom edge of the tape. **Note** the events in the list are not completely in order right now.

Event	Time (Years ago)
Formation of the earth	4.6×10^9
First known algae and fungi appear	4.0×10^9
First invertebrates appear	570×10^6
First fish appear	500×10^6
First reptiles appear	300×10^6
First amphibians appear	400×10^6
First mammals appear	200×10^6
First man-like animal	2.5×10^6
Pleistocene glaciations (most recent)	1.0×10^6
Pacific Coast Orogeny (mountain building)	70×10^6
Appalachian mountain building	350×10^6
First known plants appear	3.2×10^9
First known animals appear	1.2×10^9
Oldest rocks on the planet	3.9×10^9
First dinosaurs appear	225×10^6
Last dinosaurs disappear	66×10^6
Age of Canada	1.43×10^2
Your birth	_____

careful with the numbers... they are not in order

3. Be sure to be creative – add pictures and drawings to your timeline!

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Notes: Relative Dating with Fossils

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Relative Dating with Fossils

-Fossils are used to determine the age of rocks by the **Principle of** Faunal Succession
Life forms change through time so ... "Rocks are the same age if they contain exactly the same type of fossil organism"

-This allowed geologists to relate rock bodies, or a stratum layer of rock, located in different areas of the world—called "correlation"

-In identifying the habitat and lifestyles of extinct organisms, we assume that the same natural and physical laws have always operated (maybe at different rates.)

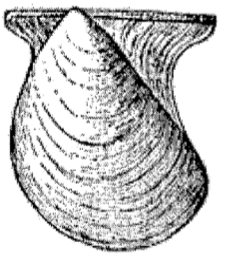
-By observing present processes, we can understand the past history and development of the earth and its inhabitants.
-This theory is called uniformitarianism
-"The present is the key to the past"

Definition of Fossil:
Fossils are only found in sedimentary rock. Why?

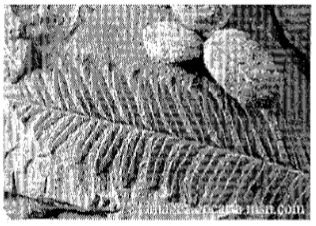
Process of original preservation:
-most fossils are only partial remains of plants or animals, generally the hard parts of the organism that was buried quickly and preserved from decay. Hard parts like shells, skeletons and teeth may be preserved.

Fossilization Processes:

1. molds
-Given enough time, even the hard parts of ~~fossil~~ animals may dissolve leaving a cavity in the hard surrounding sediment. This fossil cavity is called a mold. The mold of the interior of a shell formed when a shell fills with mud, hardens, and then becomes free of the surrounding shell.
-Trapped insects leave molds in amber (hardened pine tree sap.)



2. Casts
-If other sediment latter fills the mold and lithifies, a matching cast is formed.
-No internal structure can be seen with this type of fossilization
-This is the most common mode of preservation of many trace fossils
e.g. animal tracks, worm burrows, poo, etc



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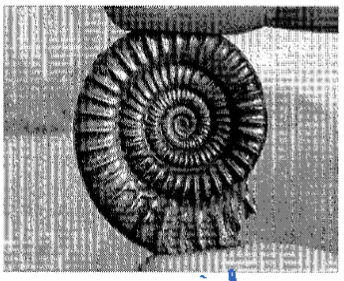
3. Carbonization

–The removal of other elements leaving the carbon behind (like peat formation)
e.g. plants usually fossilized this way

trilobite

4. Permineralization

-The original hard parts have **additional** mineral materials deposited in pore spaces.



ammonoid

5. Replacement

-Minerals in solution in pore waters replace original materials as it dissolves or decays
-With this type of fossilization, you can see the internal structure
e.g. Petrified wood is silica replacement.

Conditions necessary for the preservation of soft parts

-Soft tissues are destroyed due to decay before lithification or destruction during diagenosis. Usually they are best preserved as carbon films (carbonization) on a rock surface

-However under unusual conditions, soft part rock replicas may be preserved relatively intact.

-Ex. The world famous Burgess Shale Fossil Deposit near Field, B.C. found by Charles Walcott in 1909.

-This is what happened approximately 530 million years ago. There was no life on land and most life was small and lived along sea bottoms. A mudslide from a soft bank buried the living organisms in silt. The water was deep and low in O_2. The silt flattened, hardened (lithification) and became the sedimentary rock shale. Fossil replicas of the organisms were formed. Hundreds of millions of years later, colliding plates caused the shale to be thrown up as part of an 8,000 foot mountain. It is this unusual, detailed snapshot of life as it was 530 million years ago, replicas of soft parts and all, that makes the Burgess Shale deposit so valuable. (Note: not the actual flesh, but a fossil preserved version/shape of it.)

Therefore, the required conditions necessary for the preservation of soft tissue are:

1. rapid burial of (rock replica of)
2. live organism in
3. deep, low O_2 water followed by
4. rapid lithification of sediment.

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Another unusual event: Mammoth found in ice with flesh still intact. This is original preservation.

Index Fossils and the Necessary Characteristics

A fossil that is widespread but restricted in time is useful in correlating rocks of the same age in different areas and is referred to as "index" (or guide) fossil. The required characteristics of index fossils are:

1. They must be easy to identify from other similar fossils. They must be unique in some way
2. They must be found over a wide geographic area.
3. They must have a short time range so that they occur in only a few rock layers.
4. They must be abundant and easy to fossilize

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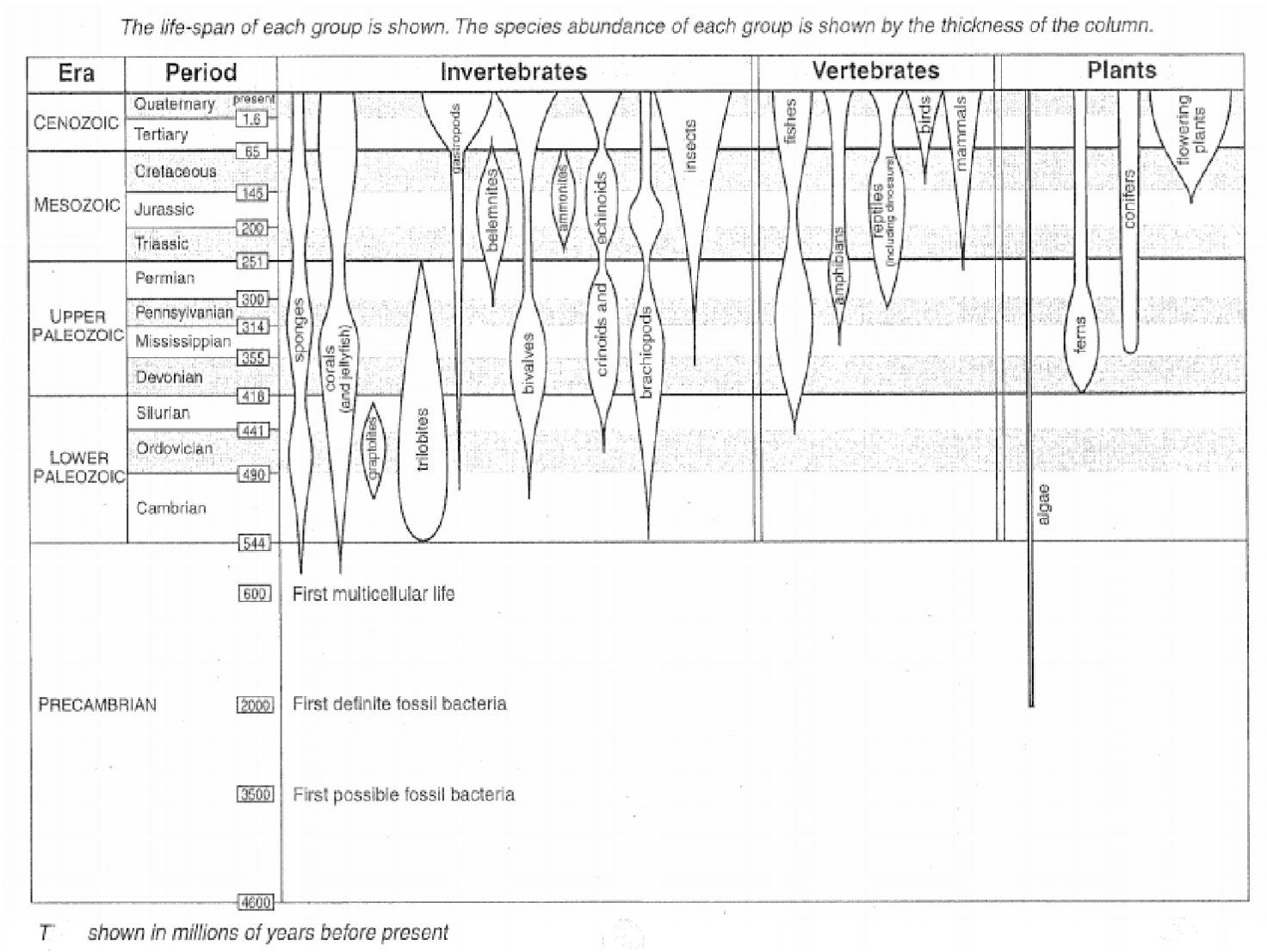
Development of Life through Time



Fossil Activity

Use the "Interpreting Earth History" (IEH) lab manual pages 91-101 and 119-131 (5th ed) to fill in the attached fossil id sheet. Find the phylum name, sub name, where they lived (marine, lake, land, etc.), when they lived, if they are extinct or not, what relatives are living today, etc. Write the information in the space provided beside each group of pictures.

GEOLOGICAL TIME SCALE

ERA	PERIOD	EPOCH	TIME m.y.	
Cenozoic Age of the Mammals	Quaternary	Holocene	0.01	early humans Australopithecus Afarensis; 0.5my ago national homo sapiens
		Pleistocene	2	pleistocene glaciation 2my ago – 10,000 yrs ago
	Tertiary	Pliocene	5	4my- hominoi most primitive humans
		Miocene	24	
		Oligocene	37	
		Eocene	58	
		Paleocene	66	
Mesozoic Age of the Reptiles	Cretaceous		144	Rockies complete; Pacific Coast Mts
	Jurassic		208	flowering plants
	Triassic		245	uplift of Rockies begins
Paleozoic Age of the Invertebrate	Permian		286	amphibians dominate; coal forests formed
	Carboniferous: Pennsylvanian		320	fish dominate
	Carboniferous: Mississippian		360	
	Devonian		408	first land plants
	Silurian		438	
	Ordovician		505	age of the graptolites
	Cambrian		570	earliest life algae
Precambrian			~~4600~~ 4.5 b.y.	⊕ formed

Based on Hamblin, *The Earth's Dynamic Systems*, 1982. Dates from Montgomery, *Physical Geology*, 1987.

It is recognized that there is some variation in the dates given in the literature.

*Approximate age of the oldest rocks.

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Phylum: ~~Arthropoda~~ Arthropod

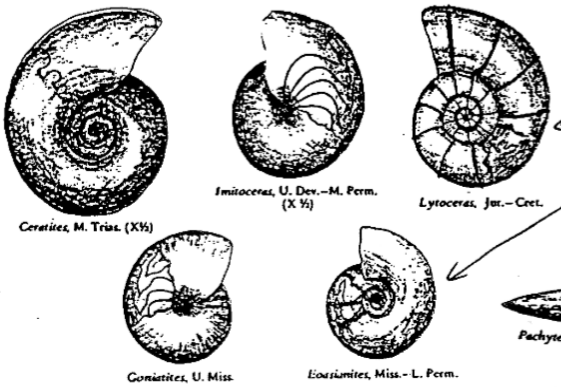
Subname: Trilobite

- segmented exoskeleton
- crabs, lobsters, spiders
-

Trilobites
↳ extinct
↳ index fossils for Camkerian and Ordovician

Phylum: Mollusca

Subname: Cephalopod



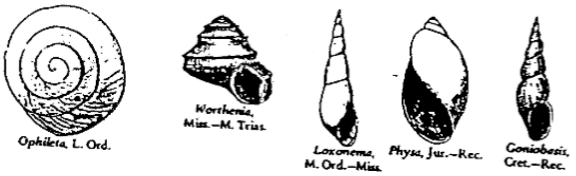
Ammonoid (extinct)
free swimming

Nautiloids

Phylum: Mollusca

Gastropod

(snails, slugs)



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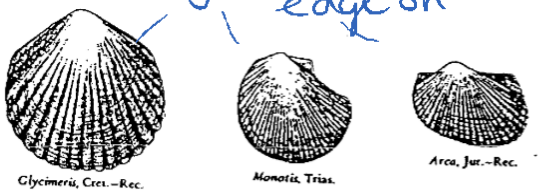
symmetrical edge on

Phylum: Mollusca

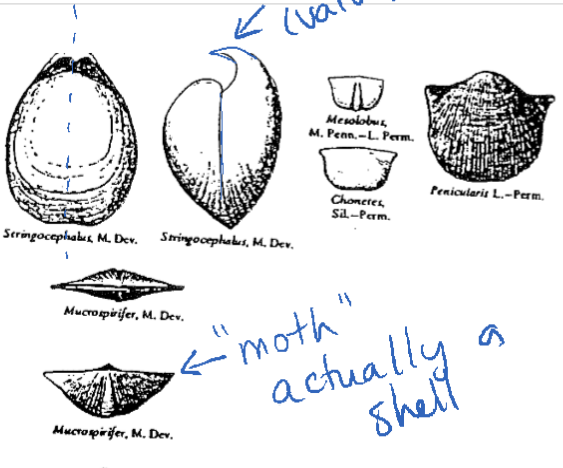
Pelecypod (Bivalves)

(clams, oysters, scallops)



Mollusca
- lots of variety
- marine, fresh water
- deep ocean to mt tops
- Cambrian to recent

"nose" (valve)

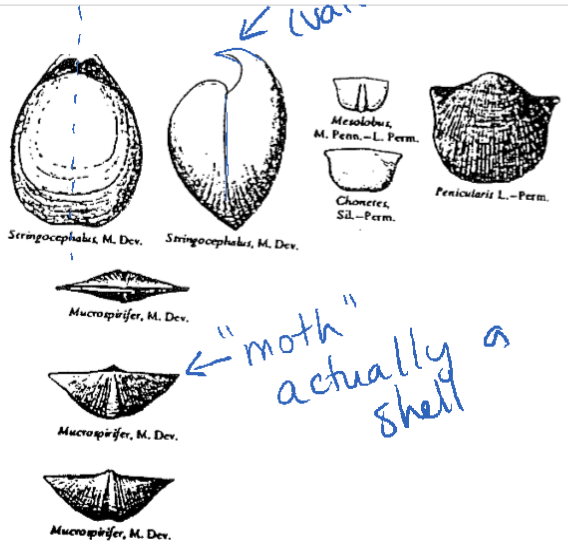


Phylum: Brachiopod

- marine invertebrates
- mostly Paleozoic, still a few today

"moth" actually a shell

- symmetrical face-on



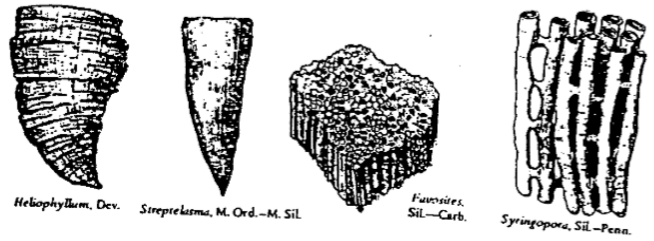
Phylum: Brachiopod

- marine invertebrates
- mostly Paleozoic, still a few today

← "moth" actually a shell

- symmetrical face-on

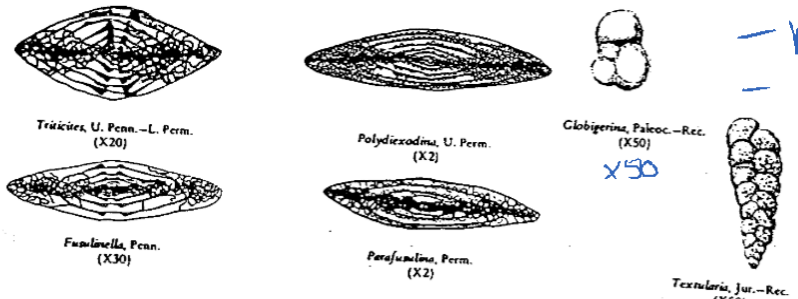
Phylum: Coelenterata (Cnidaria)



- corals
- shallow seas
- first appeared Ordovician
- still common today.

Phylum: Protazoa

Foraminifera ✱



- marine or freshwater
- precamb – now
- $CaCO_3$ (calcite) shells
- some are single celled

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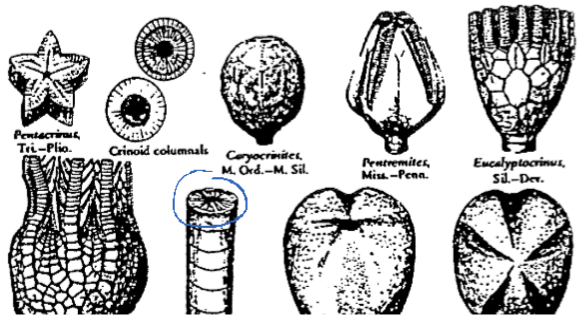
Phylum: Echinodermata

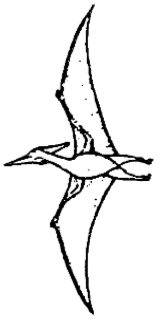


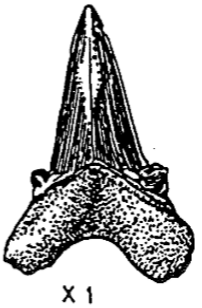
- 5-fold symmetry
- starfish, sand dollar, sea urchin
- marine
- more common in past
- calcite skeletons

sea lily

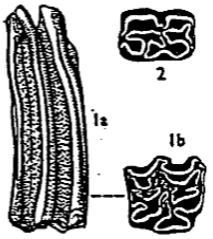
- more common in past
- calcite skeletons
- Camb. → now
- most common Carboniferous to Tertiary

Phylum: Vertebrata





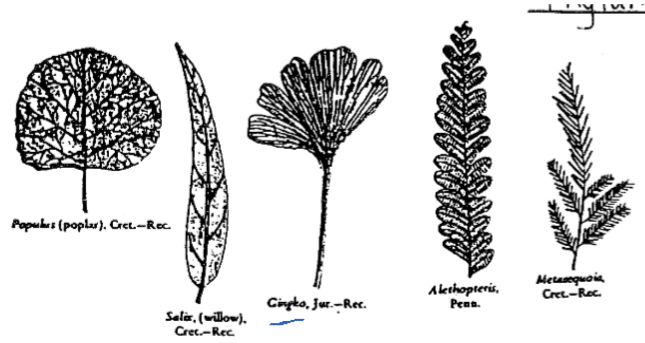
X 1



TEETH
PLEISTOCENE-HORSE

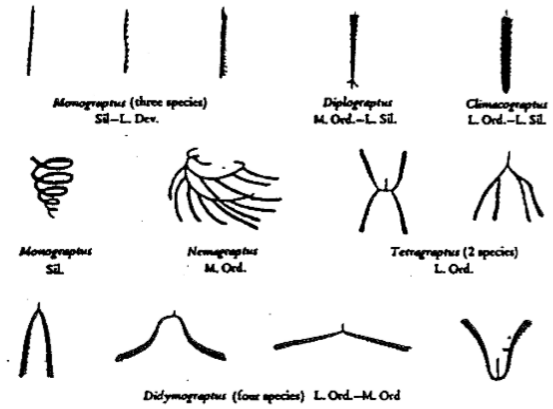
- spines
- fewer fossils since lived on land (sediment doesn't build up as quickly)
- often teeth
- fish developed in Ordovician, still exist

Phylum: plants



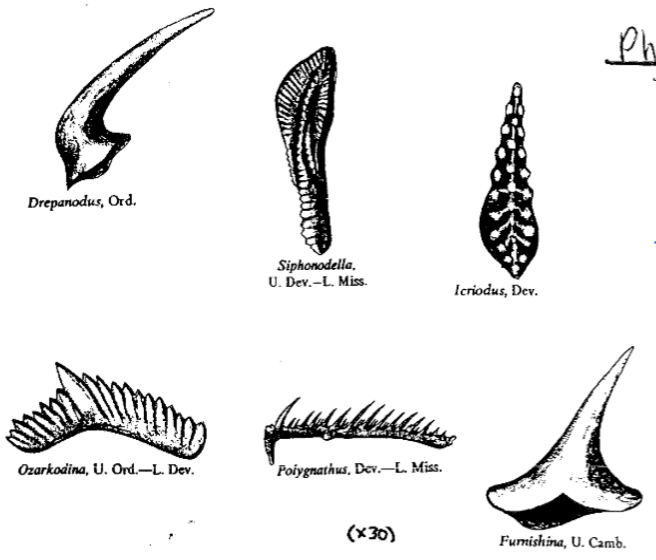
- live on land
- carbonization method of fossilization

Phylum: Graptolites = "writing on rocks"



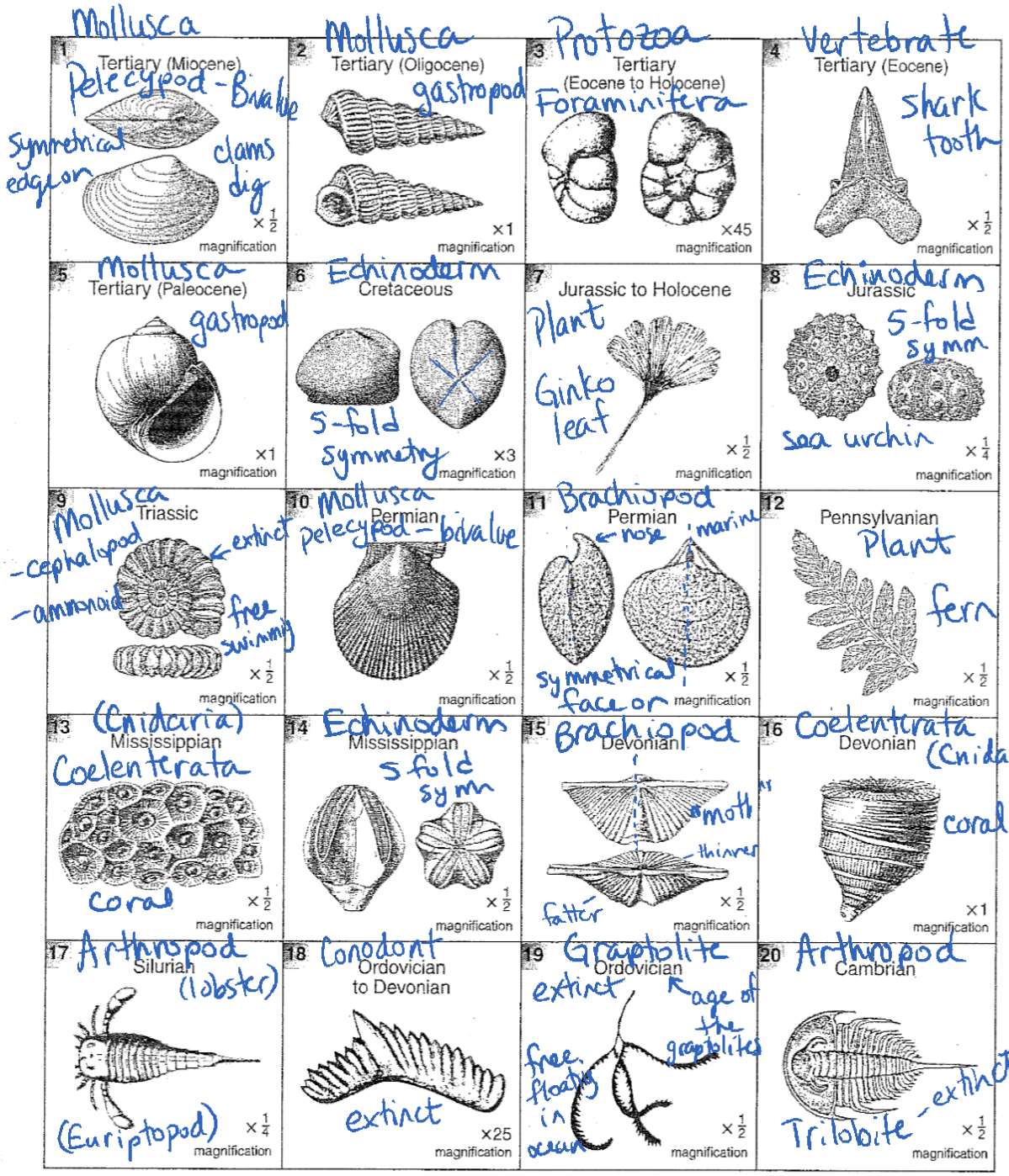
- extinct
- looks like pencil marks
- few cm for colony
- Ordovician – "Age of the Graptolites"
- free floating in ocean

Phylum: Conodonts



- extinct
- microfossils
- now classified as vertebrates
- < 1mm, med. to dark brown
- Cambrian – Triassic
- good index fossil for intercontinental correlation.

Fossil Samples

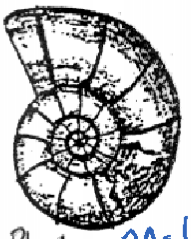


Fossil Activity (specimens)

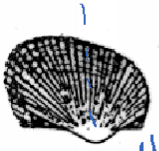
Fossil Activity: Find a fossil in the set, of the phylum indicated, and complete each row. For some phyla, there are more than one specimen to choose from.

	Phylum	Subname(s)	Period	Location	Diagram of specimen	Google information
1	Vertebrata					
2	Brachiopoda					
3	Mollusca	G				
4	Mollusca	M				
5	Mollusca	C				
6	Echinodermata					
7	Plant					
8	Arthropoda					
9	Cnidaria					

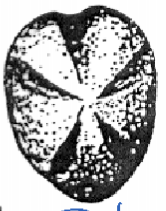
Practice Phyla Quiz

1. 

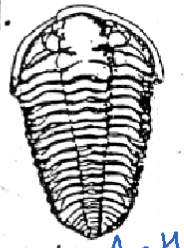
Phyla: Mollusca
Name: Cephalopod Ammonoid

2. 

Phyla: Mollusca
name: Bivalve

3. 

Phyla: Echinoderm

4. 

Phyla: Arthropod
name: Trilobite
Era dominant: Paleozoic

5. 

Phyla: Mollusca
name: Gastropod
Common relative: snails, slugs

6. 

Phyla: Protozoa
name: Foraminifera

7. 

Phyla: Brachiopod
Era: Paleozoic